NPS Imagery Data Base

Descriptions of Imagery Types

NASA LANDSAT Data Collection: Data from approximately 1985 through 1999 is currently available. Selections are provided in the library to show range, coverage, and dates available. The data is not geometrically corrected, while it has been screened for cloud cover and band quality.
North American Landscape Charicterization: A Landsat satellite image from 1972, 1982, and 1992 (each image approximately 10 years apart) of a specified area are given in a CD-Rom form. A digital elevation model (DEM) for the area covered by the images is included for orthorectification purposes. Also available in computer compatible 8mm tape format.
LANDSAT TM: Imagery from 1984 forward available.
LGSOWG Multispectral Scanner LANDSAT
LGSOWG Thematic Mapper LANDSAT
AVHRR: 1:30 resolution (m). Earlier data available, from 04/83.
MultiSpectral Scanner LANDSAT Data: Images as early as 1972 available (WRS: Landsat 1,2,3). The best possible images documented in the digital library (1 or 0 cloud coverage, best land coverage). Images as late as 1992 available (WRS: Landsat 4, 5). World Reference Systems change between 1981 and 1982, 1982 beginning the use of the WRS for Landsat 4 and 5.
MRLC Geocoded Data: Data from approximately 1988 to around 1993 or 1998 available.
CORONA: This is photography data and available in film format. This data is from one of several U.S. photo-reconnaissance satellites active from 1960 to 1972. Photography was focused on Eastern Europe and Asia. This data is included in the image library to provide earlier-dated data for each site.
Other LANDSAT Imagery: This data is available in a variety of formats, such as ftp, 8mm tape cartridge (tar), and CD-Rom. The Landsat 7 satellite provides this data, and data from July 1999 to the present is available. If LANDSAT-7 LEVEL-0R WRS-SCENE V002 is available the majority of the time LANDSAT-7 LEVEL-1 WRS-SCENE V002 is available as well.

IKONOS: 1 meter to 25 meter resolution data available from Space Imaging, Inc.. 20m data most commonly found for sites, from 1996 to present. Available to order in 7.5x7.5 tiles, 15x15 tiles, or 30x30 tiles. One meter resolution is available on a very limited basis, and 4m resolution data is available if 1m is. If 5m resolution panchromatic data is available, fused color data is available as well in most cases.
(Data price depends on agency buying and purpose bought for – research price $4000 for 20m data for Mt.Rainier, company/agency price $2500 for 20m resolution data on overlaid images.)
The 25m resolution data is Landsat. The Landsat is directly available through IKONOS, but prices are not always given through the search site (must contact for details). For Landsat data, commercial price is higher than federal government or federal government affiliate prices (for 25m Landsat data for GRSM commercially purchased data is $2850.00 as opposed to $2000.00 for the federal government or federal government affiliate). (The resolution values of 1m, 4m, 5m, etc., are the search values given by the Carterra Search and Order site [http://map2.spaceimaging.com] and are not necessarily the true value of the image. See the site for details.)

WRS System: World Reference System used to assign path and row numbers to the imagery photographed by satellites based on their orbit in reference to the earth's position. There is a WRS for Landsats 1, 2, and 3; and a separate WRS for Landsats 4 and 5. Maps are obtainable from the USGS by request.

Obtaining information listed in the catalog
The source of information and ordering for AVHRR, LGSOWG Multispectral Scanner Landsat, LGSOWG Thematic Mapper Landsat, Multispectral Scanner Landsat Data, and Thematic Mapper LANDSAT data satellite imagery cited in this catalog is from the following website:

http://edc.usgs.gov/webglis

Go to the above site and navigate to enter the catalog information to order the desired catalog imagery. All searches for the NPS site coordinates were searched through this site's search option in detail to obtain the cited data sets.

The source of information and ordering for the NASA LANDSAT Data Collection and North American Landscape Characterization data satellite imagery cited in this catalog is from the following website:

http://edcimswww.cr.usgs.gov/pub/imswelcome/

See the above site and enter the catalog information in order to order the desired catalog imagery. All searches for the NPS site coordinates were searched through this site's search option in detail to obtain the cited data sets.

IKONOS Data
Existing data is available to be searched and ordered through Carterra online at
http://map2.spaceimaging.com
A site registration must be obtained to search for data online, and this can be done through the above given IKONOS web site.

Digital Imagery/Program Definitions taken from the above listed websites for reference to these organizations/companies and their products.

AVHRR (Advanced Very High Resoluation Radiometer)
The Advanced Very High Resolution Radiometer (AVHRR) is a broad-band, four or five channel (depending on the model) scanner, sensing in the visible, near-infrared, and thermal infrared portions of the electromagnetic spectrum. This sensor is carried on NOAA's Polar Orbiting Environmental Satellites (POES), beginning with TIROS-N in 1978.

The AVHRR sensor provides for global (pole to pole) on board collection of data from all spectral channels. Each pass of the satellite provides a 2399 km (1491 mi) wide swath. The satellite orbits the Earth 14 times each day from 833 km (517 mi) above its surface.

The EROS ADAPS systematic georegistration process references AVHRR data to the Earth's surface. Through modeling the position and attitude of the TIROS satellite platforms and the scanning geometry of the AVHRR sensor, geometric distortions can be minimized. The position of the satellite is determined by an orbital model updated by ephemeris data received daily from NAVY Space Surveillance. The AVHRR sensor model characterizes the non-linear scanning of the sensor mirror. A refinement to the sensor model accounts for the displacement in longitude due to the rotation of the Earth under the satellite. All modeling is referenced to the time of acquisition. As the satellite clock time drifts, a delta time adjustment is applied. Collectively, these models comprise the geometric correction model in ADAPS. The positional accuracy of a systematic georegistration is approximately 5000 m, RMSE.

Precise georegistration positional accuracy of 1000 m RMSE, requires correlation of image features with accurately registered cartographic or image-based maps. A common practice is to use cartographic sources such as Digital Chart of the World (DCW) or hydrography data to extract easily identifiable features such as coastlines, water bodies, and rivers and to correlate them with the matching raw image locations using various techniques. The correlation process determines specific adjustments to be applied to the time, roll, and yaw parameters of the orbital model. The EDC ADAPS uses a variety of techniques depending upon the geographic location of the imagery and the volume of data to be processed.

CORONA Satellite Photography
President Clinton signed an Executive Order on 22 February 1995, directing the declassification of intelligence imagery acquired by the first generation of U.S. photo-reconnaissance satellites; the systems

code-named CORONA, ARGON and LANYARD. The order provides for the declassification of more than 860,000 images of the Earth's surface, collected between 1960 and 1972.

A complete list of mission numbers for all attempted missions is provided in the Mission Summaries of the Appendix at http://edc.usgs.gov/Webglis/glisbin/guide.pl/glis/hyper/guide/disp .

The spatial and temporal characteristics of the declassified historical satellite imagery are given here according to KH designator. For additional insight on how performance varied by mission see Mission Summaries of the Appendix. The best spatial resolution of the imagery is 6 feet (KH-6); the lowest resolution is approximately 460 feet (KH-5).

The imagery collection is organized as rolls of film and comprises more than 17,000 rolls. Each mission (e.g., 9009 or 1117-2 for bucket 2 of mission 1117) is divided into passes (or orbit revolutions), and each image frame within a pass is designated by a frame number. In order to conserve film for important areas of coverage, film was not always exposed on every pass. Additionally, the fore and aft camera film are packaged separately for missions that carried twin panoramic cameras (as did mission 1117-2). Occasionally one of the pair of cameras malfunctioned or was programmed to halt, while its mate continued to operate. Therefore, there may be fore camera film but no aft camera film, or vice versa.

LGSOWG Multispectral Landsat Data

The Landsat Ground Station Operations Working Group (LGSOWG) MSS data base lists all MSS Landsat scenes held by participating countries (excluding USA).

The Landsat system provides for global data between 82 degrees North latitude and 82 degrees South latitude.

The Landsat platforms operate from a sun-synchronous, near polar orbit imaging the same 185 km (115 miles) ground swath every 16 days (formerly 18 days on Landsats 1-3). Multispectral Scanner (MSS) are received directly from Landsats 4 and 5 by the LGSOWG network of worldwide ground stations.

The Multispectral Scanner (MSS) sensors are line scanning devices observing the earth perpendicular to the orbital track. The cross-track scanning is accomplished by an oscillating mirror; six lines are scanned simultaneously in each of the four spectral bands for each mirror sweep. The forward motion of the satellite provides the along-track scan line progression. All five Landsats have carried the MSS sensor which responds to earth reflected sunlight in four spectral bands. Landsat 3 carried an MSS sensor with an additional band, designated band 8, that responded to thermal (heat) infrared radiation.

Two types of image data are offered:

-Fully processed data with both geometric and radiometric corrections applied.

-Partially processed data with only radiometric corrections applied.

Processing Codes

-Fully Processed: MSS =CCT-P

-Partially Processed: MSS = CCT-A

Both processing levels offer either a Band-Interleaved-by-Line (BIL) or a Band-Sequential (BSQ) image data format.

Unlike previous Landsat CCT formats (Landsats 1-3), current CCT's will include a comprehensive field location and data description information superstructure. This superstructure consists of:

-A volume directory file which generally describes the data configuration and provides pointers to each data file, and

-a file descriptor record for each data file which describes the data structure within the file and provides pointers to certain fields within the file.

The entire superstructure is composed of four records. Three records (volume descriptor, text, file pointer) reside in a volume directory file. The fourth record is the file descriptor record which is the first record of each data file. The four superstructure records are similar to one another in content as well as in format.

The purpose of these records is to identify, describe and locate data in the data files. Thus, superstructure records primarily supply information about the data on the CCT rather than carrying data themselves.

To obtain additional LGSOWG MSS information regarding other technical details, ancillary products, and pricing
schedules, contact one of the:
LGSOWG Stations

The specific LGSOWG station can be determined from the first two characters of each scene's Entity ID based
upon:

XH - Argentina
XG - Australia
XB - Brazil
XC - Canada
XD - Italy (via European Space Agency)
XJ - Japan
XM - Maspalomas (via European Space Agency)
XP - Pakistan
XF - South Africa
XE - Sweden (via European Space Agency)

Online requests for these data can be placed via the U. S. Geological Survey Global Land Information System
(GLIS) interactive query system. The GLIS system contains metadata and online samples of Earth science data.
With GLIS, you may review metadata, determine product availability, and place online requests for products.

LSSOWG Thematic Mapper Landsat
Landsat 4 was launched on July 16, 1982 and was the first time that the Thematic Mapper (TM) sensor was carried on a Landsat platform. The Landsat Ground Station Operations Working Group (LGSOWG) TM data base lists all TM Landsat scenes held by participating countries (excluding USA).

The processing subsystem at each LGSOWG station may vary, but usually consists of the TM data being processed and reformatted onto a digital tape for use during the geometric correction process.

The TM processing steps include:
-Correcting and validating the mirror scan and payload correction data
-Providing for image framing by generating a series of scene center parameters
-Synchronizing telemetry data with video data
-Estimating linear motion deviation of scan mirror/scan line corrections
-Generating benchmark correction matrices for specified map projections
-Producing along- and across-scan high-frequency scan line matrices

A TM scene has an IFOV of 30 square meters in bands 1-5 and 7 while band 6 has an IFOV of 120 square meters on the ground.
Landsat 4 launch date was 07/16/82, and Landsat 5 launch was 03/01/84.
The Thematic Mapper (TM) is an advanced, multispectral scanning, earth resources sensor designed to achieve higher image resolution, sharper spectral separation, improved geometric fidelity and greater radiometric accuracy and resolution than the MSS sensor. TM data are sensed in seven spectral bands simultaneously with band 6 sensing thermal (heat) infrared radiation.
Processing Codes
-Fully Processed: MSS =CCT-P
-Partially Processed: MSS = CCT-A

Both processing levels offer either a Band-Interleaved-by-Line (BIL) or a Band-Sequential (BSQ) image data format.
Unlike previous Landsat CCT formats (Landsats 1-3), current CCT's will include a comprehensive field location and data description information superstructure. This superstructure consists of:
-A volume directory file which generally describes the data configuration and provides pointers to each data file, and
-a file descriptor record for each data file which describes the data structure within the file and provides pointers to certain fields within the file.

To obtain additional LGSOWG TM information regarding other technical details, ancillary products, and pricing
schedules contact one of the LGSOWG Stations.
The specific LGSOWG station can be determined from the first two characters of each scene's Entity ID based
upon:

YG - Australia
YB - Brazil
YC - Canada
YD - Italy (via European Space Agency)
YJ - Japan
YM - Maspalomas (via European Space Agency)
YP - Pakistan
YF - South Africa
YE - Sweden (via European Space Agency)

Online requests for these data can be placed via the U. S. Geological Survey Global Land Information System
(GLIS) interactive query system. The GLIS system contains metadata and online samples of Earth science data.
With GLIS, you may review metadata, determine product availability, and place online requests for products.

Multispectral Landsat Data
Landsats 1 through 3 operated in a near-polar orbit at an altitude of 920 km with an 18-day repeat coverage cycle. These satellites circled the Earth every 103 minutes, completing 14 orbits a day. Eighteen days and 251 overlapping orbits were required to provide nearly complete coverage of the Earth's surface with 185 km wide image swaths. The amount of swath overlap or sidelap varies from 14 percent at the Equator to a maximum of approximately 85 percent at 81 degrees north or south latitude. Landsats 1 through 3 satellites carried return beam vidicon (RBV) cameras and the MSS sensor. The RBV cameras did not achieve the popularity of the MSS sensor. The MSS sensor scanned the Earth's surface from west to east as the satellite moved in its descending (north-to-south) orbit over the sunlit side of the Earth. Six detectors for each spectral band provided six scan lines on each active scan. The combination of scanning geometry, satellite orbit, and Earth rotation produced the global coverage necessary for studying land surface change. The resolution of the MSS sensor was approximately 80 m with radiometric coverage in four spectral bands from the visible green to the near-infrared (IR) wavelengths. Only the MSS sensor on Landsat 3 had a fifth band in the thermal-IR wavelength.
Landsats 4 and 5 carry both the MSS and the TM sensors; however, routine collection of MSS data was terminated in late 1992. The satellites orbit at an altitude of 705 km and provide a 16-day, 233-orbit cycle with a swath overlap that varies from 7 percent at the Equator to nearly 84 percent at 81 degrees north or south latitude. These satellites were also designed and operated to collect data over a 185 km swath. The MSS sensors flown aboard Landsats 4 and 5 are identical to the ones that were carried on Landsats 1 and 2. The MSS and TM sensors primarily detect reflected radiation from the Earth's surface in the visible and IR wavelengths, but the TM sensor provides more radiometric information than the MSS sensor. The wavelength range for the TM sensor is from the visible (blue), through the mid-IR, into the thermal-IR

portion of the electromagnetic spectrum. Sixteen detectors for the visible and mid-IR wavelength bands in the TM sensor provide 16 scan lines on each active scan. Four detectors for the thermal-IR band provide four scan lines on each active scan. The TM sensor has a spatial resolution of 30 meters for the visible, near-IR, and mid-IR wavelengths and a spatial resolution of 120 meters for the thermal-IR band.

The National Landsat Production System (NLAPS) processing system is currently used by the EDC for processing data. This system replaced EDIPS in the mid-1990's. A Digital Cassette Recording System (DCRSi) cassette drive is used to supply serial image data to NLAPS. The NLAPS produces systematic, precision, and terrain corrected digital products. The NLAPS products also offer variable pixel sizes, image orientations, resampling techniques, horizontal datums, map projections, and WRS scene center offsets.
For further information on the NLAPS MSS processing system, refer the National Landsat Archive Production System (NLAPS).

The characteristics of the MSS and TM bands were selected to maximize the band's capabilities for detecting and monitoring different types of Earth resources. For example, MSS band 1 can be used to detect green reflectance from healthy vegetation, while MSS band 2 is designed for detecting chlorophyll absorption in vegetation. MSS bands 3 and 4 are ideal for recording near-IR reflectance peaks in healthy green vegetation and for detecting waterland interfaces.

MSS Bands 4, 2, and 1 can be combined to make false-color composite images, where band 4 controls the amount of red, band 2 the amount of green, and band 1 the amount of blue in the composite. This band combination makes vegetation appear as shades of red with brighter reds indicating more vigorously growing vegetation. Soils with no or sparse vegetation will range from white (sands) to greens or browns, depending on moisture and organic matter content. Water bodies appear blue. Deep, clear water appears dark blue to black in color, while sediment-laden or shallow waters appear lighter in color. Urban areas appear blue-gray in color. Clouds and snow appear as bright white, and they are usually distinguishable from each other by the shadows associated with the clouds.

MSS scenes from Landsats 4 and 5 have an instantaneous field of view (IFOV) of 68 meters in the cross-track direction by 82 meters in the along-track direction (223 by 272.3 feet, respectively). To understand this concept, consider a ground scene composed of a single 82- by 82-m area. The scan monitor sensor ensures that the cross-track optical scan is 185 km at nominal altitude regardless of mirror scan nonlinearity or other perturbations of mirror velocity. Cross-track image scan velocity is nominally 6.82 meters per microsecond. After 9.958 microseconds, the 82- by 82-m image has moved 67.9 meters. The sample taken at this instant represents 15 meters of previous information and 68 meters of new information. Therefore, the effective IFOV of the MSS detector in the cross-track direction must be considered to be 68 meters which corresponds to a nominal ground area of 68 meters, by 82 meters at the satellite nadir point. Using the effective IFOV in area calculation eliminates the overlap in area between adjacent pixels.

Landsats 1 through 3 provided Earth coverage similar to Landsats 4 and 5. However, the higher altitude of Landsats 1 through 3 resulted in a different swathing pattern with the IFOV being 56 meters in the cross-track direction by 79 meters in the along-track direction (183.7 feet by 259.2 feet, respectively).
The resolution for the MSS sensor is shown below:

Landsats 1-3	Landsats 4-5	(meters)
Band 4	Band 1	79/82*
Band 5	Band 2	79/82
Band 6	Band 3	79/82
Band 7	Band 4	79/82
Band 8**		237

* As a result, the nominal altitude was 920 km for Landsats 1, 2, and 3. Nominal altitude for Landsats 4 and 5 is 705 km. The resolutions are approximately 79 and 82 meters respectively.
** Landsat 3 only.
Background information and status of Landsat satellites.

Satellite	Launched	Decommissioned	Sensors
Landsat 1	July 23, 1972	January 6, 1978	MSS and RBV

Landsat 2	January 22, 1975	February 25, 1982	MSS and RBV
Landsat 3	March 5, 1978	March 31, 1983	MSS and RBV
Landsat 4	July 16, 1982	*	TM and MSS ***
Landsat 5	March 1, 1984	**	TM and MSS ***

* in standby mode used for range and command as of December 14, 1993.
** currently operational
*** MSS data acquisition suspended in 1992

The radiometric range of bands for the MSS sensor is shown below: (Handbook, 1979 and 1984, USGS).

Landsats 1-3	Landsats 4-5	Wavelength (micrometers)
Band 4	Band 1	0.5 - 0.6
Band 5	Band 2	0.6 - 0.7
Band 6	Band 3	0.7 - 0.8
Band 7	Band 4	0.8 - 1.1
Band 8		10.4 - 12.6

Landsat TM

The Land Remote Sensing Policy Act of 1992 (Public Law 102-555) officially authorized the National Satellite Land Remote Sensing Data Archive (NSLRSDA) and assigned responsibility to the Department of the Interior which has been delegated to the USGS EDC. In addition to its Landsat data management responsibility, the EDC investigates new methods of characterizing and studying changes on the land surface with Landsat data.

Landsats 4 and 5 carry both the MSS and the TM sensors; however, routine collection of MSS data was terminated in late 1992. The satellites orbit at an altitude of 705 km and provide a 16-day, 233-orbit cycle with a swath overlap that varies from 7 percent at the Equator to nearly 84 percent at 81 degrees north or south latitude. These satellites also were designed and operated to collect data over a 185-km swath. The MSS and TM sensors primarily detect reflected radiation from the Earth's surface in the visible and near-infrared (IR) wavelengths, but the TM sensor with its seven spectral bands provides more radiometric information than the MSS sensor. The wavelength range for the TM sensor is from the visible, through the mid-IR, into the thermal-IR portion of the electromagnetic spectrum. Sixteen detectors for the visible and mid-IR wavelength bands in the TM sensor provide 16 scan lines on each active scan. Four detectors for the thermal-IR band provide four scan lines on each active scan. The TM sensor has a spatial resolution of 30 meters for bands 1 through 5, and band 7, and a spatial resolution of 120 meters for band 6.

Geometric correction removes geometric distortions in an image based on knowledge of the satellite and sensor, and remaps the image to a regular grid in a standard map projection. This is accomplished by constructing a mapping between pixel coordinates in the image and geographic coordinates on the surface of the Earth. This mapping is referred to as the forward transformation.

NLAPS has the capability to produce systematically-corrected, precision-corrected, and terrain-corrected products for specified users (see Data Organization in USGS information/ordering site).

The Space Imaging Image Processing System (IPS) has the capability to produce precision-corrected, geocoded, mosaiced, and terrain-corrected products. Insufficient control points in the Control Point Library that first require a single-band (Band 4) tape be produced and processed on the Control Point Extraction System for control point selection. Upon successful completion, the product is reprocessed via the EIPS. Digital elevation model and digital terrain model data are ingested through IPS for terrain-corrected and mosaic products.

A 3-band digital data tape is provided with each film product request and is used in the Film Process Generation System. The 3-band digital data are ingested, Look Up Tables are constructed, and the ordered RGB (i.e., red-green-blue filtration) is assigned for output. The latent image is processed using a Colorfire-240 film recorder. Further processing is completed per customer request. These products include paper print, color positive transparency, or processed negative transparency.

Space Imaging initiated a Fast Format for TM digital data. The general formatting criteria follows:
-Field definitions strictly follow American National Standards Institute (ANSI) and International Organization for Standardization (ISO) standards.
-Only band sequential image structure is supported. Geometric corrections to the data are done one band at a time.
-Image files consist of a single band of data.
-A digital product is referred to as a volume set. Individual tapes are referred to as volumes. A volume set may have one or more volumes depending on image size and output tape density. Multi-resolution data sets have a volume set for each resolution.

The characteristics of the MSS and TM bands were selected to maximize detecting and monitoring different types of Earth resources. For example, band 1 of TM data penetrates water for bathymetric mapping along coastal areas and is useful for soil-vegetation differentiation and for distinguishing forest types. TM band 2 detects green reflectance from healthy vegetation, and TM band 3 is designed for detecting chlorophyll absorption in vegetation. TM Band 4 data is ideal for detecting near-IR reflectance peaks in healthy green vegetation and for detecting water-land interfaces. The two mid-IR red bands on TM (bands 5 and 7) are useful for vegetation and soil moisture studies and for discriminating between rock and mineral types. The thermal-IR band on TM (band 6) is designed to assist in thermal mapping, and is used for soil moisture and vegetation studies.
Typically, TM Bands 4, 3, and 2 can be combined to make false-color composite images where band 4 represents the red, band 3 represents the green, and band 2 represents the blue portions of the electromagnetic spectrum. This band combination makes vegetation appear as shades of red, brighter reds indicating more vigorously growing vegetation. Soils with no or sparse vegetation range from white (sands) to greens or browns depending on moisture and organic matter content. Water bodies will appear blue. Deep, clear water appears dark blue to black in color, while sediment-laden or shallow waters appear lighter in color. Urban areas appear blue-gray in color. Clouds and snow appear bright white. Clouds and snow are usually distinguishable from each other by the shadows associated with clouds.

A Landsat-4 or -5 TM scene has an instantaneous field of view (IFOV) of 30 meters by 30 meters (900 square meters) in bands 1 through 5 and band 7, and an IFOV of 120 meters by 120 meters (14,400 square meters) on the ground in band 6.
The resolution for the TM sensor is shown below:

Landsats 4-5	Resolution (meters)
Band 1	30
Band 2	30
Band 3	30
Band 4	30
Band 5	30
Band 6	120
Band 7	30

The TM sensor is an advanced, multispectral scanning, Earth resources instrument designed to achieve higher image resolution, sharper spectral separation, improved geometric fidelity, and greater radiometric accuracy and resolution than the MSS sensor. The TM data are scanned simultaneously in seven spectral bands. Band 6 scans thermal (heat) infrared radiation.
Spectral range of bands and spatial resolution for the TM sensor are:

Landsats 4-5	Wavelength (micrometers)	Resolution (meters)
Band 1	0.45-0.52	30
Band 2	0.52-0.60	30
Band 3	0.63-0.69	30
Band 4	0.76-0.90	30
Band 5	1.55-1.75	30

Band 6	10.40-12.50	120
Band 7	2.08-2.35	30

The EDC offers systematically corrected 10-year and older TM image data to the general public. These data are radiometrically and geometrically corrected, using the satellite model and platform/ephemeris information. The image data also are rotated and aligned to a user-defined map projection.
The EDC systematically processed data are offered either in a band-interleaved-by-line (BIL) or a band-sequential (BSQ) image data format.
Other processing formats are available from the EDC to the U.S. Government and its Affiliated Users (USGAU) only. The formats are:

Map Registered Data: These data are radiometrically and geometrically corrected using the satellite model and platform/ephemeris information. The image data are rotated and aligned to a user-defined map projection, using ground control points to improve the satellite model.

Terrain Corrected Data: These data are radiometrically and geometrically corrected using the satellite model and platform/ephemeris information. The image data are rotated and aligned to a user-defined map projection, using ground control points and a digital terrain model. The rotation, alignment, and registration are done to improve the satellite model and to improve the geodetic inaccuracy caused by the parallax error that occurs because of local terrain elevation.

Both the Map Registered and Terrain Corrected formats are processed in BSQ or BIL image data formats.
NLAPS-processed digital tape products include:
-Image data and the metadata describing the image
-Processing procedure, which contains information describing the process by which the image data were produced
-DEM data and metadata describing them (available only with terrain corrected products)

For information on the TM digital product format descriptions, refer to:
-"National Landsat Archive Production System (NLAPS) Systematic Format Description Document"
-"National Landsat Archive Production System (NLAPS) Precision and Terrain Corrected Formats Description Document"

The Space Imaging Fast Format volume set contains a header file, image files, and a trailer file.
The first file on each volume, a Read-Me-First file, contains header data. It is in American Standard Code for Information Interchange (ASCII) format and adheres to ANSI and ISO standards. The header file contains a single 1536-byte ASCII record. All alphanumerics are left justified, and all numerics are right justified.
All image files contain only one TM band of image pixels. There are no header records within the image file, nor are there prefix or suffix data in the individual image records. Image data may be blocked or unblocked.
The blocking factor is a procedure used to minimize the number of digital tapes required to accommodate a full-scene, seven-band image set. Image data are written to tape in individual records and between each record is an inter-record gap of 0.35 inch, separating image file records. Unblocked data contain one line of image data per tape record.
The last volume of the Fast Format image set includes a trailer file. The trailer file contains ephemeris information to compute the approximate spacecraft position for each pixel in the image. This file is in ASCII format and adheres to ANSI and ISO standards.

The structure for a single-volume and a multi-volume set are presented below. Each file is followed by an End-Of-File (EOF) marker. An End-Of-Volume (EOV) marker consists of three EOF markers.

Single Volume Volume Set	Multi Volume Volume Set	
	Volume 1	Volume 2
Header File	Header File	Header File
EOF	EOF	EOF

Band 1	Band 1	Band 5
EOF	EOF	EOF
Band 2	Band 2	Band 6
EOF	EOF	EOF
Band 3	Band 3	Band 7
EOF	EOF	EOF
Band 4	BAND 4	EOV
EOF	EOF	Trailer File
Band 5	EOV	
EOF	Trailer File	
Band 6		
EOF		
Band 7		
EOF		
EOV		
Trailer File		

MRLC Geocoded Data

The Multi-Resolution Land Characteristics (MRLC) project was established to provide multi-resolution landcover data of the conterminous United States from local to regional scales. A centerpiece of MRLC is an objective to develop a national 30-meter landcover characteristics data base using Landsat thematic mapper (TM) data. This is a cooperative effort among six programs within four U.S. Government agencies: the U.S. Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP); the U.S. Geological Survey's (USGS) National Water Quality Assessment Program (NAWQA); the Department of Interior National Biological Service's (NBS) Gap Analysis Program (GAP); the USGS's Earth Resources Observation Systems (EROS) Data Center; the National Oceanic and Atmospheric Administration's (NOAA) Coastal Change Analysis Program(C-CAP); and the EPA's North American Landscape Characterization (NALC) project. The four agencies formed
the MRLC Consortium for the purpose of purchasing Landsat TM images covering the conterminous U.S. that could form the basis of a system for obtaining baseline multi-scale environmental characteristics as well as a mechanism for monitoring and assessing environmental change at the regional level. Each of these programs had an immediate need for the images but found that individual purchases were not cost effective. However, a joint purchase was found to be very cost effective, saving the Federal Government several million dollars in data costs and data processing. This collaboration allows for each program to continue the pursuit of its own objective, but also increases the potential for joint landscape characterization efforts.

The EROS Data Center (EDC), on behalf of the MRLC Consortium, negotiated an agreement with Space Imaging allowing the purchase of 430 Landsat TM scenes representing one-time coverage of the conterminous United States. The agreement further provided the option to obtain an additional 100 scenes, at no cost to allow for multitemporal coverage of selected portions of the United States. Additionally, the agreement allowed the EDC to identify up to an additional 150 scenes which had been previously purchased for non-MRLC activities, such as scenes purchased by the GAP prior to the purchase agreement, to be used for MRLC activities.

The TM images were precision corrected and registered to a map base. This entailed the selection of image and planimetric source control points for use in developing the model for precision correction. Control point sources included 1:100,000-scale USGS digital line graph (DLG) data and 1:24,000-scale USGS topographic maps for areas within the U.S. and 1:50,000-scale maps for areas of the included scenes that fall outside the U.S. borders. The DLGs are components of the National Digital Cartographic Data Base (NDCDB), and they are comprised of the various thematic layers (transportation, hydrography, hypsography, political boundaries, etc.) depicted on the 1:100,000-scale topographic map series (USGS, 1989).

The map control points contain X, Y, and elevation values and were corrected for relief displacement. The image was rectified and resampled, using cubic convolution, to a UTM-projected output image comprised

of 30- by 30-meter pixels. A full terrain correction was applied by correcting for the effects of relief displacement, on a pixel-by-pixel basis, using the DEM image previously created. A verification of registration quality was performed using control points selected from a map source. Scenes must meet quality restrictions of total RMSEs of less than 1.0 pixel. Approximately 12-plus control points were used to verify the image-to-map registration accuracy.
All images were geometrically corrected to the following default specifications:
-UTM projection
-Terrain correction applied
-30-meter pixels
-NAD83 datum
-Cubic convolution resampling
If required to meet individual program requirements, the geometrically corrected data were projected to user-specified projection parameters. Registration accuracy meets the requirements of plus or minus one pixel (30 meters) RMSE.
The spatial resolution is the same of Landsat TM.

NASA Landsat Data Collection
The NASA Landsat Data Collection (NLDC) is a compilation of Landsat multispectral scanner (MSS) scenes and Landsat thematic mapper (TM) scenes from four distinct data collections. These collections include the Global Change Landsat Data Collection (GCLDC), the Humid Tropical Forest Project (HTFP) collection of source scenes and products; a collection of data from the Committee on Environment and Natural Resources Research (formerly the Committee on Earth and Environment Sciences), and ongoing NASA Landsat data purchases starting with the 1996 fiscal year. The NLDC scenes have been screened for cloud cover and band quality resulting in a high grade, high quality data compilation.

The GCLDC collection contains Landsat TM scenes that were purchased by NASA from Space Imaging, formerly the Earth Observation Satellite Company, under a special agreement to promote the use of shared data in global change research. The HTFP, the largest component of NASA's Landsat Pathfinder Program, contains Landsat MSS and TM scenes collected over the past 20 years. The goal of the HTFP is to globally map deforestation in the humid tropical forests. The CEES collection is the result of an effort to coordinate data needs among several Federal agencies (e.g., Environmental Protection Agency, Department of the Interior agencies, National Oceanic and Atmospheric Administration, Department of Defense). These Landsat TM scenes were collected for a variety of research projects. Ongoing NASA purchases of Landsat TM data support NASA scientists and their affiliated researchers in programs and projects including the NASA Research and Analysis Program; the Global Land Cover Test Sites Project; the HTFP, the International Biosphere-Geosphere Programme, the NASA Applications Program; and the Landsat-7 Science Team.

North American Landscape Characterization Imagery
The North American Landscape Characterization (NALC) Project is a component of the Landsat Pathfinder Program. The NALC data set is comprised of hundreds of triplicates (i.e., multispectral scanner (MSS) data acquired in the years 1973, 1986, and 1991 plus or minus one year, thus, the name triplicate). The NALC triplicates also include digital elevation model data. The specific temporal windows vary for geographical regions based on the seasonal characteristics of the vegetation cover.

Landsat 7 Imagery
The Landsat-7, level-1 Worldwide Reference System (WRS) data collection contains partially processed (radiometrically corrected or
radiometrically and geometrically corrected WRS scenes) from the Enhanced Thematic Mapper Plus sensor flown aboard the Landsat-7 satellite.
The primary mission objectives of the Landsat-7 Project are to provide high quality visible and infrared images of landmasses and near-coastal
areas and to continue to populate the existing Landsat data archive.

Landsat-7 ETM+ sensor data are framed into approximately 183-kilometer by 170-kilometer increments or scenes. The nominal centers for the Landsat-7 scenes map to a global notation system called the Worldwide Reference System (WRS), using Path and Row designators that equate to the satellite's 233-orbit cycle (i.e., the same orbit cycle used for Landsat satellites 4 and 5). The scenes are referred to as WRS scenes.

Landsat-7 level-1R products contain data that have been radiometrically corrected, while level-1G products contain data that have both been radiometrically and geometrically corrected. Level-1R products are distributed in HDF format. Level-1G products are distributed in HDF, FAST-L7A, and GeoTIFF formats. Currently, data are distributed at the single WRS-scene granule level. Distribution of subintervals and partial subintervals is pending.

Landsat ETM+ data are distributed in accordance with the Land Remote Sensing Policy Act of 1992, Public Law 102-555, as amended, and related contractual agreements. Landsat ETM+ data also are collected by foreign receiving stations. Purchasers are subject to individual foreign distribution site policy and pricing directives.

IKONOS

Since its founding in late 1994, Denver, Colorado-based Space Imaging has quickly become a world leader in digital Earth information to better map measure, monitor, and manage the world we live in - from our national assets to global crop production. Space Imaging's already diverse collection of resources grew with the launch of IKONOS, the world's first one-meter resolution, commercial imaging satellite, on September 24, 1999. The addition of the IKONOS satellite to Space Imaging's portfolio enables the company to produce more economical information products with delivery timelines that far exceed the standards in the marketplace.

Since its founding in late 1994, Denver, Colorado-based Space Imaging has quickly become a world leader in digital Earth information to better map, measure, monitor, and manage the world we live in - from our national assets to global crop production. Space Imaging's already diverse collection of resources grew with the launch of IKONOS, the world's first one-meter resolution, commercial imaging satellite, on September 24, 1999. The addition of the IKONOS satellite to Space Imaging's portfolio enables the company to produce more economical information products with delivery timelines that far exceed the standards in the marketplace.